7. EDUCATION AND PUBLIC OUTREACH

The Laboratory for Atmospheres actively participates in NASA's efforts to serve the education community at all levels and to inform the general public. The Laboratory's educational outreach component is consistent with the Agency's objectives to enhance educator knowledge and preparation, supplement curricula, forge new education partnerships, and support all levels of students. Laboratory activities include continuing and establishing collaborative ventures and cooperative agreements; providing resources for lectures, classes, and seminars at educational institutions; and mentoring or academically-advising all levels of students. The public outreach component seeks to make scientific and technological advances of the Laboratory accessible to the public and increase their understanding of why and how such advances affect their lives. The public outreach activities within the Laboratory are very effective and in some cases, world class. Through these programs, the Laboratory seeks to ensure that the Nation's diversity is reflected and utilized effectively.

Interaction with Howard University and Other Historically Black Colleges and Universities

A part of NASA's mission is to initiate broad-based aerospace research capability by establishing research centers at the nation's Historically Black Colleges and Universities (HBCUs). The Center for the Study of Terrestrial and Extraterrestrial Atmospheres (CSTEA) was established in 1992 at Howard University in Washington, D.C. as a part of this initiative. The Laboratory for Atmospheres started its collaboration with CSTEA in the second five-year period of NASA funding. It is the goal of NASA and mission of CSTEA to establish at Howard a self-supporting, world-class facility for the study of terrestrial and extraterrestrial atmospheres, with special emphasis in training African Americans in aerospace-based sciences and engineering.

The Laboratory continues its research and educational activity with Howard University's CSTEA program. A Technical Review Committee site visit was held to evaluate the CSTEA program, make recommendations for their cooperative agreement with the Laboratory, help them with their strategic planning for future growth, and develop new funding sources for their atmospheres program. The Laboratory works with CSTEA to promote the Howard University Program in Atmospheric Sciences (HUPAS), the only HBCU program that offers the Masters and Ph.D. degrees in atmospheric science. Scientists from our Laboratory contribute to the HUPAS program as lecturers, advisors to graduate and undergraduate students, and adjunct professors teaching a number of their courses. A series of seminars has been given at Howard University as supplemental instruction in their Atmospheric Sciences Program.

The Laboratory also continued its cooperative agreement with Howard University, CSTEA HBCU Academic and Research Consortium (CHARC). CHARC is a partnership that includes the Howard University's CSTEA, five Historically Black Colleges and Universities, and GSFC. This consortium funds students from the five HBCUs to earn a Masters degree from Howard University in the atmospheric sciences while par-

ticipating in NASA research. Laboratory scientists served as mentors for some of the CHARC students during the summer. Additionally, the Goddard Howard Fellowship in Atmospheric Sciences (GoHFAS) was established in 1999 to broaden the mentor, research, and degree opportunities to HBCU students not affiliated with the CHARC agreement. In the first year, approximately five GoHFAS students matriculated within the Laboratory. They conducted important research and interacted with scientists and engineers. Collaborative experimental programs included aerosol satellite validation measurements using ground-based and airborne instruments, and Raman Lidar measurements of ozone using the Howard-Beltsville optical site.

In addition to the Laboratory involvement with CSTEA, the Laboratory interacted with HBCUs in other capacities. The Laboratory hosted research faculty on sabbatical from Howard University's Department of Mathematics and Chemistry throughout the year. A recent HUPAS graduate joined the Laboratory's Atmospheric Chemistry Branch and will pursue his doctoral degree through a Goddard-sponsored research and study fellowship. The Laboratory also participated in a NASA/Morgan State University research exchange to explore potential research collaborations between the two institutions.

Graduate Student Summer Program

The Laboratory for Atmospheres participated in a program administered by the Universities Space Research Association, in collaboration with the Goddard Space Flight Center's Earth Sciences Directorate. This program offered a limited number of graduate student research opportunities each Summer. The program was designed to stimulate interest in interdisciplinary Earth science studies by enabling selected students to pursue specially tailored research projects in conjunction with Goddard scientific mentors. For further information, consult the World Wide Web (http://phoenix.gvsp.usra.edu/gssp/).

K-12 Education

Laboratory staff participated in K-12 education in a variety of ways. Laboratory scientists routinely presented lectures and demonstrations to K-12 schools and youth groups to help develop an early interest in science. Many Laboratory scientists have also mentored students in grades K-12. The Eleanor Roosevelt High School Science and Technology Internship Program enabled high school students to perform research on mesoscale atmospheric processes under the mentorship of Laboratory scientists. This program exemplifies a unique three-way partnership between the Laboratory, its contractors, and Eleanor Roosevelt High School. Members of the Laboratory served as judges for local science fairs and made presentations at High School Career Days to foster interest in NASA-related research. Additionally, Laboratory scientists continued to mentor K-12 students through the Summer High School Apprenticeship Research Program (SHARP). One Laboratory scientist was awarded Director's Discretionary Funding for FY2000 for outreach related to Girl Scouts of Maryland and Earth Science education.

In the areas of curriculum development and educator training, the Laboratory played a significant role in 1999. Several Laboratory scientists served on panels for local school districts (e.g. Montgomery County) to decide on high school re-districting and new curricula. As a result, Earth Science material has been or will be included as part of an enhanced science program at several area schools.

Key Laboratory scientists were also instrumental in collaborating with the GSFC Education Office to host a Meteorology conference for K-12 educators in Maryland, New Jersey, and Pennsylvania. This conference provided background information and curriculum material on Goddard missions related to weather and climate and how to effectively integrate them into classroom discussion. Also, Laboratory scientists conducted workshops on various weather and climate-related topics for visiting K-12 educators in summer programs like Students United with NASA Becoming Enthusiastic About Math and Science (SUNBEAMS) and NASA Educational Workshop for Secondary Math, Science, and Technology Teachers (NEWMAST). A Laboratory scientist was also the keynote speaker at the 1999 Baltimore City School Title I Educators' Workshop. Additionally, the same scientist continues to serve as a Host Researcher for the JASON Foundation for Education's JASON XI expedition "Going to Extremes". The JASON expeditions reach thousands of students and teachers around the word with interactive learning experiences.

University Education

At the university level, Laboratory scientists have taught undergraduate and graduate courses at universities; given seminars and lectures; participated in mentorships for teachers and students under a variety of GSFC programs; and advised degree-seeking students. Four Laboratory scientists supervised undergraduate students and twenty-two supervised graduate students. Twenty-two Laboratory scientists have official affiliations (i.e. adjunct or visiting professor) with a university and fourteen regularly teach university-level courses.

Our scientists are involved as teachers in a variety of other settings. In a venture with other Goddard Laboratories, our scientists participated in delivering an MIT course for credit on the subject of Techniques in Remote Sensing. This course for MIT students took place during the winter semester break 1999-2000. The course was an Independent Activity Period course (IAP) during which students spent a week at Goddard and a week at MIT. The Laboratory presented lectures for 1 1/2 days during this seminar series. One Laboratory scientist taught a two-week course at Federal University in Rio de Janeiro, Brazil on global warming. He also spent a one-month sabbatical at Scripps Institute of Oceanography interacting with faculty and students.

Laboratory scientists mentored five undergraduate students and nine graduate students during the summer of 1999 through various programs. Additionally, the Code 910/970 Summer Institute on Atmospheric and Hydrospheric Science brought about fifteen undergraduate students to Goddard for two months of intensive research. Some of the

students return to the Laboratory to work on other programs, and some are mentored by Laboratory scientists for their thesis work at their home institutions.

Monsoon 2 CD-ROM and Other Educational Tools

The Monsoon is an interactive multimedia application on CD-ROM created to stimulate students and faculty in grades 9-12 to investigate and understand monsoon and data assimilation processes. In 1999, the CD-ROM passed the Earth Science Education Product review which certifies the material for distribution to the education community. The CD-ROM contains three primary elements: the Monsoon Presentation, the Data Visualizer, and the Teacher's Guide.

The Data Visualizer gives graphical answers to questions about temperature, precipitation, and wind for six cities over the period 1980 to 1995. There are 12,000 graphs embedded in the CD-ROM, which may be accessed by clicking on one interface screen. Teachers and students can do comparison studies using both assimilated and station data products. Examples for using the Visualizer in student research projects are included in the Teacher's Guide.

The Teacher's Guide and Student Activity book are available on the CD-ROM and in print. They include curriculum materials that focus on climate variation and development of data analysis skills. The books provide a performance-based format that aligns with new education standards. In addition to the monsoon resources already on the CD-ROM, this guide includes temperature data captured every 5-10 minutes for a few weeks of the winter of 1998-1999. The guide also includes global data extracted from the Interdisciplinary Data collection at the Goddard Space Flight Center. Teachers and students can also select from a variety of hands-on activities, classroom demonstrations, three short-term research exercises, and six long-term investigation projects. A variety of resources are offered, including connections to Global Learning and Observations to Benefit the Environment (GLOBE) program activities, and guidance on writing lab reports and grading student research. Selections from the National Research Council's National Science Education Standards (NSES) have been included to assist teachers in adopting the inquiry-driven learning methodology and style that is supported by the Monsoon CD-ROM Teacher's Guide and Data Visualizer.

An additional file contains long-term, monthly, temperature and precipitation data that encourage the user to explore further. Included are data sets for Bombay, Calcutta, London, Los Angeles, Seoul, and Washington, D.C. Further information on the CD-ROM may be obtained from World Wide Web (http://dao.gsfc.nasa.gov/monsoon_cd/).

In addition to the Asian-Monsoon CD-ROM, Laboratory groups also submitted various lithographs, fact sheets, and posters to the Earth Science Enterprise Product review on subject matter related to clouds, El Niño/La Niña, global warming, aerosols, and ozone. A Laboratory scientist received Director's Discretionary Funds to develop mini-education supplements for use by the weathercasters and educators to expose students to

science related to the TRMM. The supplements were distributed to educators and broadcasters and are currently available on-line at the TRMM Web site (http://trmm.gsfc.nasa.gov).

Public Outreach

Informing the public of how their tax dollar investments are working for them within the Laboratory is a critical subset of the Center and Agency public outreach mission. Laboratory scientists, working with other laboratories at Goddard and outside institutions, have passed their knowledge and interest in Earth and space science to the general public via public information and education programs.

The TRMM project continued its comprehensive Education/Outreach program in which Laboratory personnel were funded by Director's Discretionary Fund (DDF) resources to promote TRMM science to the public. Seventy on-air weathercasters around the country were served by this effort in 1999. TRMM scientists in the Laboratory regularly appeared on major media outlets (Earth and Sky Radio, CBS, NBC, ABC, and CNN) this year in support of the mission. In addition, Laboratory personnel have spoken at and conducted several outreach workshops in support of TRMM.

In addition to TRMM, Laboratory science stories routinely penetrated major media outlets. The Goddard Public Affairs Office estimates that 50 million viewers tuned in to Laboratory-related science news in 1999. The Laboratory's scientists, images, and animations have appeared in the media, including TV segments with ABC's Peter Jennings and NBC's Tom Brokaw, and top billing of Goddard and NOAA images of hurricanes in *Time*, *Life*, and the covers of *Popular Science*, *Newsweek*, *Der Spiegel*, *National Geographic* and *The Weekly Reader*. Four Laboratory scientists were featured in popular radio programs for public education reaching a combined audience of more than 2 million listeners. They discussed subject matter related to ozone, global warming, and clouds.

The Laboratory's presence in the media will likely expand due to new initiatives established in 1999. A collaboration with the Discovery Channel was initiated with Total Ozone Mapping Spectrometer Camera (TOMS-CAM) to raise awareness about atmospheric ozone issues. Various projects are in development to release TRMM, TOMS, and AVHRR products to the public through The Weather Channel. Two groups within the Laboratory were awarded DDF resources to produce a documentary on ozone and to develop a presentation for popular weather broadcasters, respectively.

Laboratory efforts were not limited to formal outreach outlets (e.g. media). Several informal public outreach venues were utilized. Laboratory staff created a permanent display on the three-dimensional temperature structure of the Earth for the GSFC Visitor Center. The TRMM Office provided a booth for visiting teachers. Laboratory scientists forwarded answers to science and engineering questions to The Mad Scientist Network, a group based at Washington University in St. Louis that answers questions submitted to them by students all over the world. Laboratory scientists contributed to

Goddard Scientific Visualization Studio efforts to collaborate with the Smithsonian Institution, the American Museum of Natural History (NYC), Disney World EPCOT, and the White House in communicating scientific discoveries to the public.

The Laboratory has also received its share of awards in the area of public outreach in 1999. The Terra outreach effort received the Goddard Annual Award for Outreach. The group also was recognized by Popular Science magazine for its award-winning Web site: NASA's Earth Observatory.

GOES Server

A Web server continues to provide recent GOES images on-line, including full-resolution sectors for all of the United States for the last two days. In addition, there are extensive scrapbooks of digital movies and pictures of important weather events observed by the GOES-8 and GOES-9 satellites since they were launched in 1994 and 1995, respectively.

Terra Outreach Synopsis

Under the direction of Yoram Kaufman (Code 913), Claire Parkinson (Code 971), and David Herring (Code 913), a coordinated effort is underway to foster greater cooperation and synergy among various outreach groups within the EOS community. As such, each of the activities described below receives contributions from various persons strategically located in different organizations and/or codes within the community.

The Terra Project Science Office has written and printed thousands of copies of a Terra mission overview brochure (hardcopies available from Charlotte Griner). The layout and design of the brochure, as well as funding for its printing, came from Code 900. Additionally, this brochure, as well as many more images, animations, and information, is available on the Terra Web site (http://terra.nasa.gov), which is also maintained by the Terra Project. An EOS Aqua Overview Brochure is being developed by the Aqua Project Scientist and Outreach Scientist.

The Terra and Aqua project teams created NASA's Earth Observatory Web site (http://earthobservatory.nasa.gov). This Web environment is the NASA Web portal where the general public goes to learn about the Earth. It showcases new images and science results from EOS missions. The focus in its first year of operation was Sea-viewing Wide Field-of-View Sensor (SeaWiFS), TRMM, Landsat-7, SeaWinds, and Terra. All resources produced for the Earth Observatory are freely available for use by the EOS community, museums, educators, public media, regional "stakeholders," environmental awareness groups, and interested members of the general public. (While leadership for this site resides in Code 913, significant contributions to its development are coming from Codes 900, 902, 912, 921, 922, 923, 935, 971, and 3200 at the Jet Propulsion Laboratory (JPL); as well as the American Museum of Natural History and East Carolina University.)

As a pathfinder for the Earth Observatory, the Terra Outreach Team continued to maintain the Global Fire Monitoring Web site, under the direction of Drs. Chris Justice (U. of Virginia) and Yoram Kaufman. The URL is http://modarch.gsfc.nasa.gov/fire_atlas. (Significant contributions toward construction of this site came from Dr. Justice's team at UVa, as well as Codes 902, 912, 913, and 922.)

To provide overarching guidance and review for the Terra outreach activities, as well as to flag mature new science results ready for public release, an Executive Committee for Science Outreach (ECSO) continues to operate. This committee is chaired by Dr. V. Ramanathan, of the Scripps Institute's Center for Clouds, Chemistry, and Climatology. The purpose of this committee is to "harvest" new Terra science results that are ready for public release, as well as to help temper the presentation of new results with respect to socio-political implications they may have.

Finally, to meet the public media's (primarily TV, newspapers, and our Earth Observatory Web site) requirements for quick access to satellite imagery relevant to significant, newsworthy Earth events (e.g., severe storms, floods, El Niño, volcanic eruptions, wildfires), the Terra Project formed a Rapid Response Network, headed by David Herring (Code 913), Asst. Terra Project Scientist. After launch, this network will enable us to access and produce remote sensing imagery over targets of interest within a matter of hours to days after acquisition.

NASA/NOAA: Earth Science Electronic Theater 2000

The NASA/NOAA Earth Science Electronic Theater (Etheater) uses interactive computer driven displays at near "IMAX" size to give a powerful tool for promoting Earth science. Scientists from the various Earth science disciplines work directly with the Visualization and Analysis Laboratory (VAL) visualizers to develop scientifically accurate visualizations. The Electronic Theater takes on new dimensions each time another scientist speaks to imagery designed and assembled in support of their area of expertise. Etheater visualizations are rendered at High Definition TV (HDTV) quality, the highest resolution possible, and thus can be immediately used in a host of other applications (i.e. National Television Standards Committee (NTSC) TV, QuickTime movies, Web graphics, etc.). QuickTime versions of each Etheater visualization, will be added to the e-theater Web page (http://Etheater.gsfc.nasa.gov) along with an explanation of the scientific significance and the origin of the data.

Using advanced computer technology and a very large, panoramic projection screen, the e-theater allows the presenter to interactively manipulate imagery and data animations. The impressive scale achieved by the wide e-theater display contributes to the unique audience impact. Furthermore, these unique capabilities allow for spontaneous speaker/audience interactions.

Visualizations produced by the NASA Goddard VAL/912, as well as other Goddard and NASA groups using NASA, NOAA, ESA, and NASDA Earth science datasets contin-

ue to be shown around the world using new display technologies. The Electronic Theater has been presented at universities, high schools, museums, and Government laboratories to scientists and the general public. Most recently, the Etheater traveled to South Africa in support of the Safari 2000 Terra ground truth experiment.

We continue to demonstrate methods for visualizing, interpreting, comparing, organizing and analyzing immense HyperImage remote sensing data sets and three-dimensional numerical model results. We call the data from many new Earth sensing satellites: HyperImage data sets, because they have such high resolution in the spectral, temporal, and spatial domains. The traditional numerical spreadsheet paradigm has been extended to develop a scientific visualization approach for processing HyperImage data sets and 3-D model results interactively. The advantages of extending the powerful spreadsheet style of computation to multiple sets of images and organizing image processing were demonstrated using the Distributed Image SpreadSheet (DISS). The DISS is being used as a high performance testbed application for the Next Generation Internet (NGI).

HDTV: Video Server: "Turn Key" HDTV

The introduction of commercial HDTV technology signals a profound paradigm shift in the ability to scientists to communicate scientific information to other scientists, managers and the general public. The quality improvement over standard NTSC television is so great that it must be seen to be appreciated. The US sponsored HDTV digital video standard allows the utilization of extremely low-cost standard computer technology for the distribution and display of HDTV material. This makes it possible to avoid the purchase of extraordinarily expensive proprietary HDTV equipment. The VAL has had considerable experience over the last several years in making ultra-high (HDTV) resolution scientific visualizations for the Earth Science Electronic Theater. This puts the VAL in a unique position to capitalize on the conversion from NTSC to HDTV. The VAL is developing short HDTV pieces featuring different science concepts.

The VAL is putting these clips on a computer based HDTV video server. This enables us to project finished, high definition presentations with affordable, lightweight equipment. Using this new technology, scientists can easily give polished, portable, wide screen HDTV presentations. This "turn-key capability also enables NASA to use the HDTV quality at NASA HQ, for museums, and the broadcast media. It is worth noting that HDTV is the new TV broadcast standard. TV networks will phase out NTSC standards within the next 6 years.

Museum Support

VAL actively works with several museums in creating new, innovative Earth Science displays. A short list of some of these museums include the Smithsonian National Museum of Natural History (NMNH), the Smithsonian Air & Space Museum, the American Museum of Natural History (AMNH) in NY, the Virginia Science Center,

and the Houston Museum of Natural History. In conjunction with large museums, we are developing science presentations that will be made accessible and available to smaller museums.

One successful museum activity is the Earth Today exhibit. The "Earth Today" exhibit evolved from an earlier Smithsonian exhibit, the HoloGlobe exhibit. The Earth Today is a permanent exhibit in the Smithsonian National Air & Space Museum. It contains all of the original information contained in the HoloGlobe exhibit, but has expanded the focus to include near-real-time data displays. These near-real-time data presently include global cloud cover, global water vapor, sea surface temperature, sea surface temperature anomalies, biosphere, and earthquakes. Earth Today won the virtual exhibition category of the Smithsonian Exhibition Awards Program in 1999. VAL personnel were actively involved in all phases of the development of this exhibit. VAL personnel continue to actively promote advancements in this exhibit. These refinements include: improvements in the computer coding, the inclusion of new and/or higher resolution data sets, (such as products from TRMM, TOMS, Terra and, when available, Aqua), and establishing a version of Earth Today that will run on many mid-level PC's and also a version that will run on the Web.

Another Museum effort is Global Links. Global Links is an exhibition in the planning phase at the Smithsonian National Museum of Natural History (NMNH). This exhibit will feature the four main earth science spheres, atmosphere, biosphere, hydrosphere and geosphere. The exhibit will focus on these different systems and explain what we know about the interdependency and delicate balance between these systems. VAL staff worked closely with the museum and NASA scientists to develop the initial concepts used in this exhibit. The VAL personnel continue to work with the museum in the refinement of those concepts. The Global Links exhibit provides the perfect opportunity to develop strong content material to explain Earth Science concepts.

Global Learning and Observations to Benefit the Environment (GLOBE)

The Laboratory continues to contribute to the Goddard Scientific Visualization Studio effort in support of the GLOBE Project, jointly with the Goddard Scientific Applications and Visualization Branch. GLOBE is a White House program led by Vice President Al Gore as a worldwide science and education program coordinating the work of students, teachers, and scientists to monitor the global environment.

NASA/NBC-4 (WRC-TV) ESIP-3 Cooperative Agreement

Laboratory scientists are continuing to participate in a Cooperative Agreement Notice (CAN) Earth Science Information Partners (ESIP-3) Project with NBC-4. The NASA/NBC-4 Meteorological/Scientific Visualization for Broadcast Television News project is intended to accomplish two goals. The first is to increase the exposure of Earth Science data to a much broader user community, the American people, by promoting such EOS missions as TRMM, Landsat 7 and newly launched Terra through

innovative visualizations on WRC-TV and WeatherNet4. The second is to optimize the previously developed tools for rapid display and value-added product creation of both ESE and commercial remote sensing data sources through valuable partnerships with public and corporate organizations. In addition, we will merge the power of GIS technology and visualization technology to provide easy-to-understand pictures in two and three dimensions for television news and weather broadcasts. These data sets are integrated into television weathercasts on WRC-TV in Washington, DC, and offered to other NBC owned and operated facilities worldwide. The Goddard developed technology for animation of long day/night sequences of colorized GOES images is being transferred to WRC-TV for use in regular weather broadcasts. Visualization and Analysis Lab has considerable experience in making ultra-high resolution weather visualizations. These visualizations are of great utility for HDTV and are made available to WRC-TV for use in the early broadcast phases of HDTV as the station converts from standard NTSC.

Digital Library

The digital library Web site is presently under construction. VAL has been tasked to collect earth science imagery and presentation material for NASA HQ. The images come from all the Earth Science disciplines from different NASA centers. This collection of images is being used in the NASA Earth Science Enterprise Science Implementation Plan. In the near future, this database will be available to NASA public outreach personnel, such as the Headquarters staff, the speakers bureau, museums, and teachers. We plan to expand this existing collection to also contain a comprehensive collection of EOS images, Quicktime animations of data, and scientific explanations along with appropriate meta data collected from the different NASA centers.